Coulomb excitation of the neutron-deficient mercury isotopes

Nick Bree

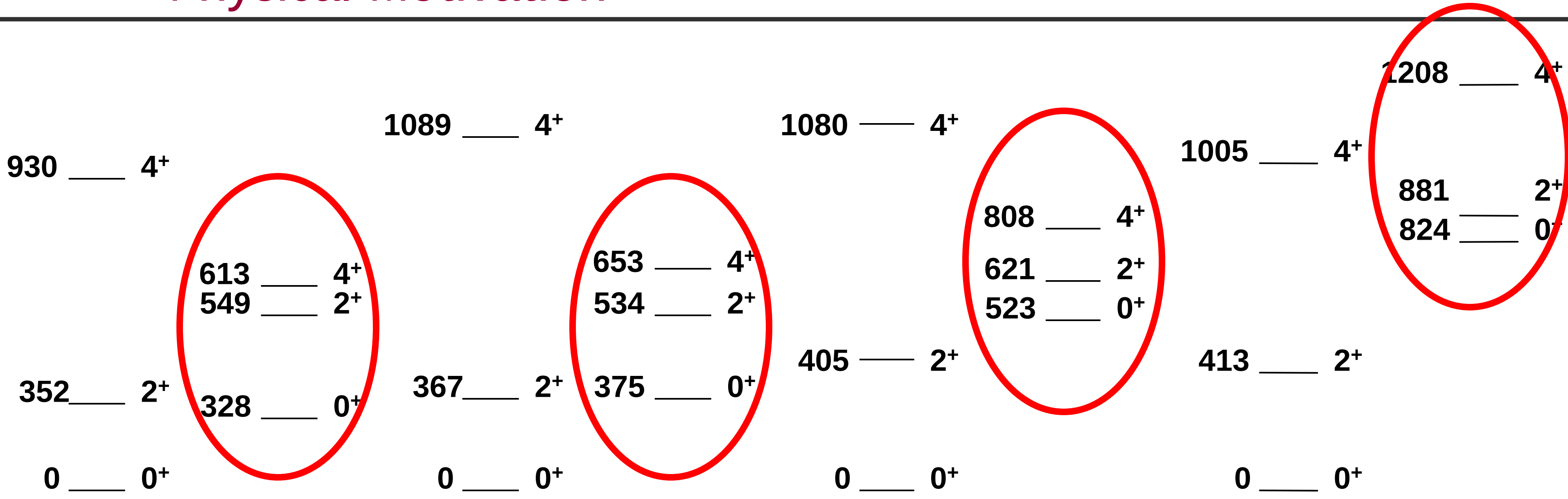
IKS, K.U. Leuven

A. Andreyev, B. Bastin, P.A. Butler, M. Carpenter, J. Cederkäll, E. Clement, T.E. Cocolios, A. Deacon, D. DiJulio, J. Diriken, A. Ekström, S. Freeman, L. Fraile, T. Grahn, M. Guttormsen, B. Hadinia, K. Hadynska, M. Hass, R.-D. Herzberg, M. Huyse, D.G. Jenkins, R. Julin, Th. Kröll, R. Krücken, V. Kumar, A.C. Larsen, P. Marley, S. Martin-Haugh, P.J. Napiorkowski, R. Orlandi, J. Pakarinen, N. Patronis, A. Petts, P.J. Peura, E. Piselli, P. Rahkila, A. Robinson, M. Scheck, S. Siem, K. Singh Chakkal, J.F. Smith, I. Stefanescu, G. Tveten, J. Van de Walle, P. Van Duppen, D. Voulot, F. Wenander, K. Wrzosek and M. Zielinska

Content

- Physics motivation
- Experimental set-up
- Analysis of $^{182,184,186,188}Hg$
- Conclusion and future perspectives

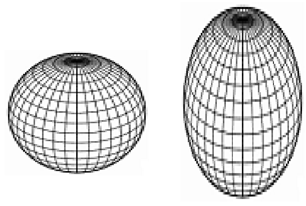
Physical Motivation



^{182}Hg ^{184}Hg ^{186}Hg ^{188}Hg

Ground state band: slightly oblate deformation $\beta_2 \approx -0.15$

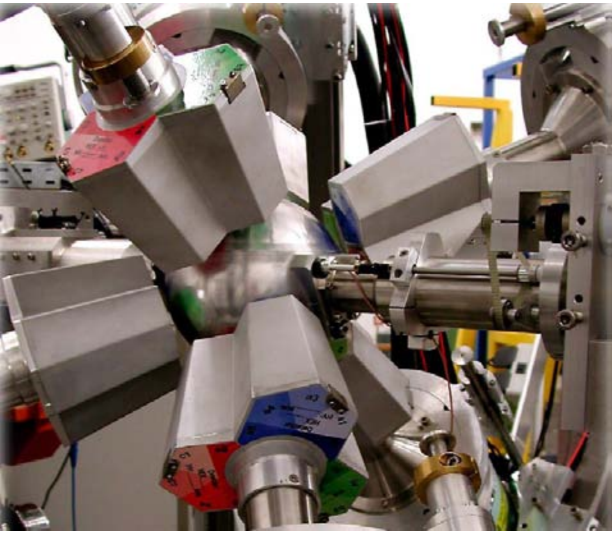
Excited band: prolate deformation $\beta_2 \approx +0.25$

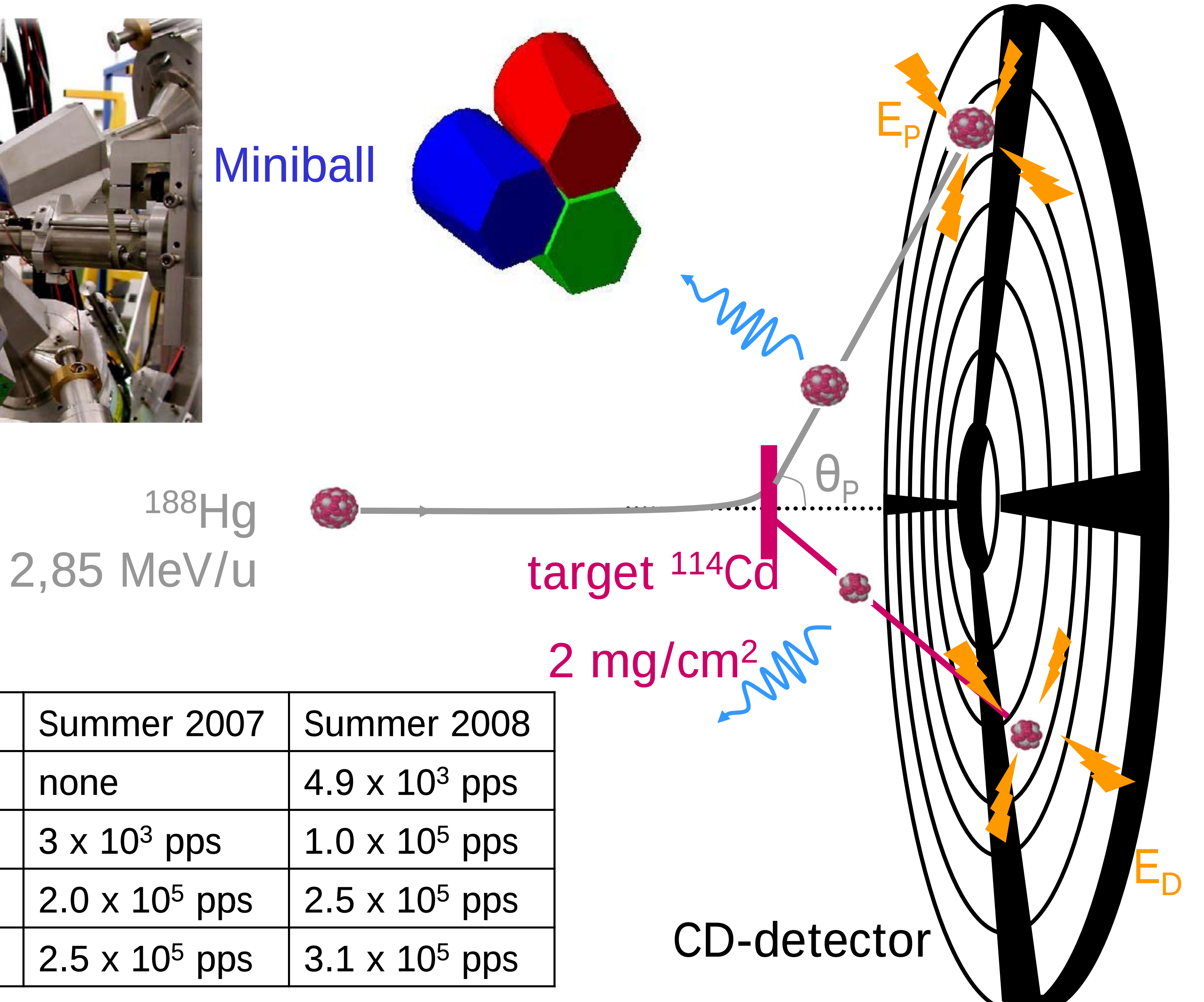


Coulomb excitation: the transitions observed reveal information on:

- Mixing between the different bands (transitional matrix elements)
- Information on the deformation (quadrupole moments)

Experimental set-up

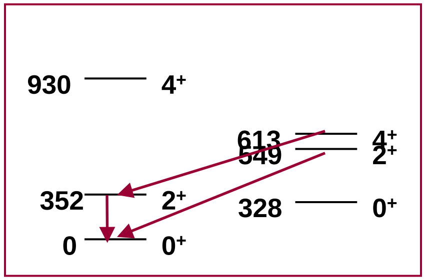


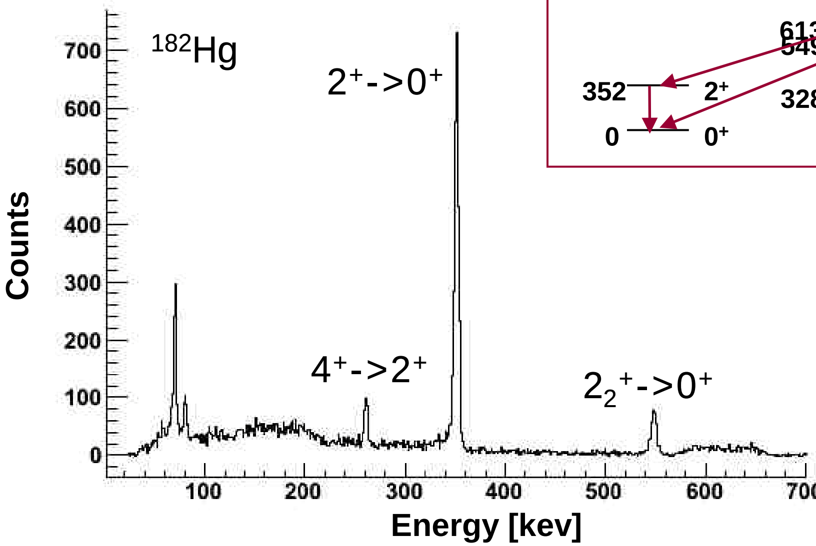


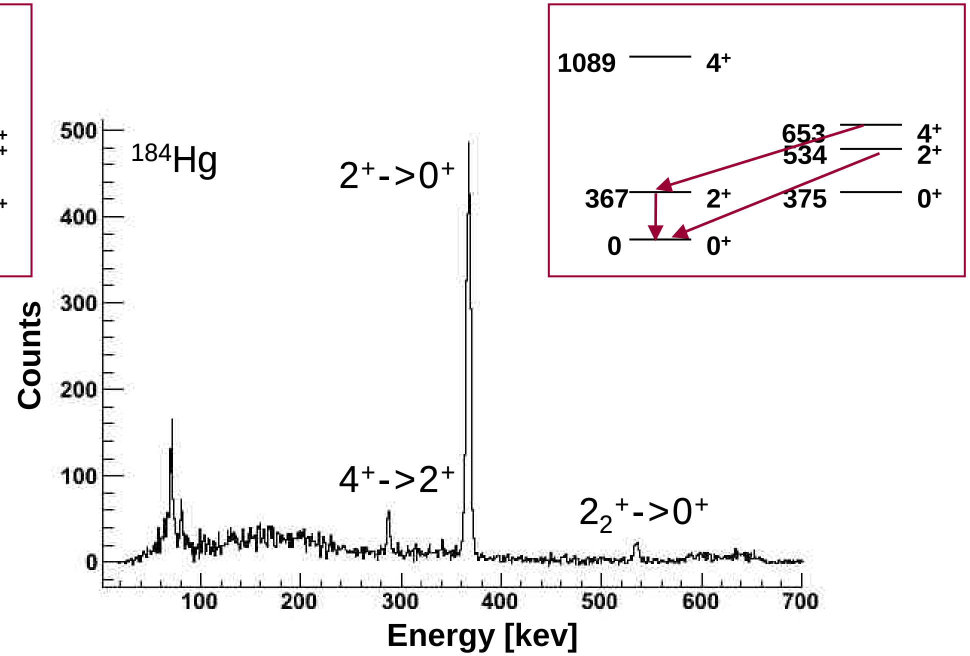
Isotope	Summer 2007	Summer 2008
^{182}Hg	none	4.9 x 10^3 pps
^{184}Hg	3 x 10^3 pps	1.0 x 10^5 pps
^{186}Hg	2.0 x 10^5 pps	2.5 x 10^5 pps
^{188}Hg	2.5 x 10^5 pps	3.1 x 10^5 pps

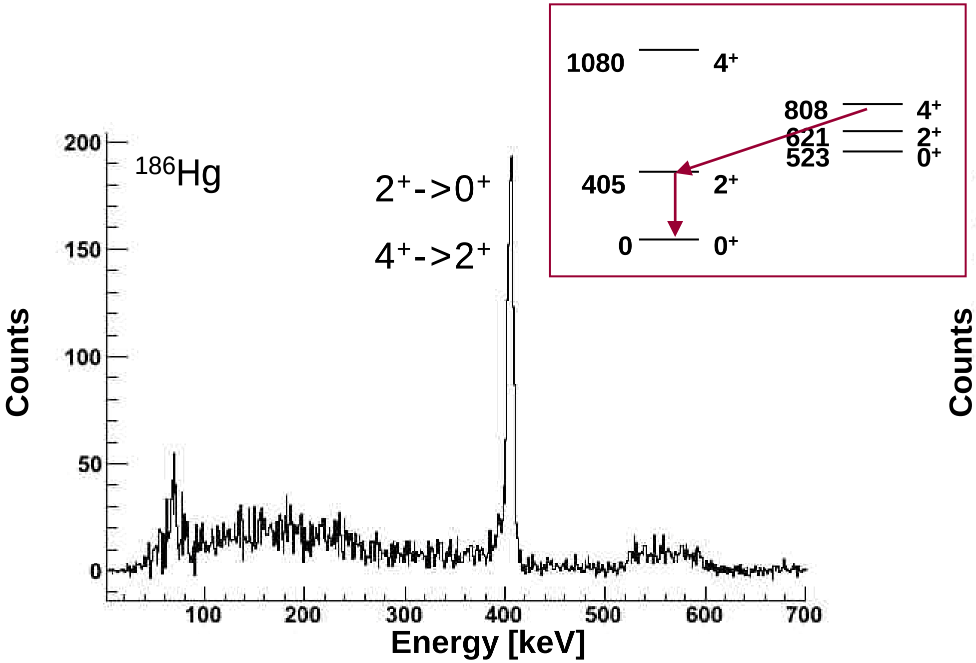
Analysis of $^{182,184,186,188}Hg$

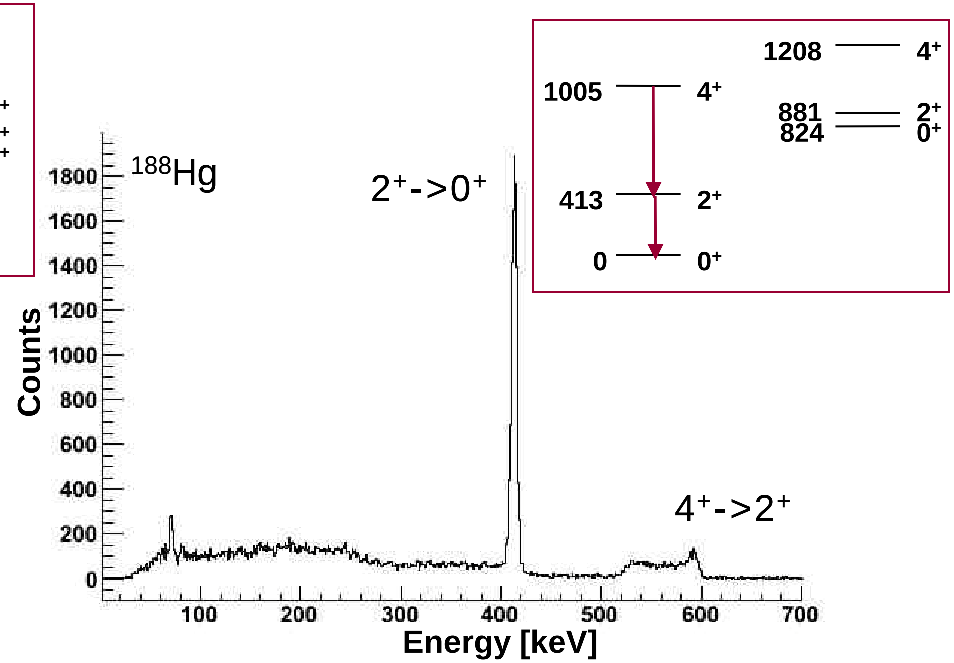
Summer of 2008: 2.85 MeV/u on $^{112,114}Cd$ target





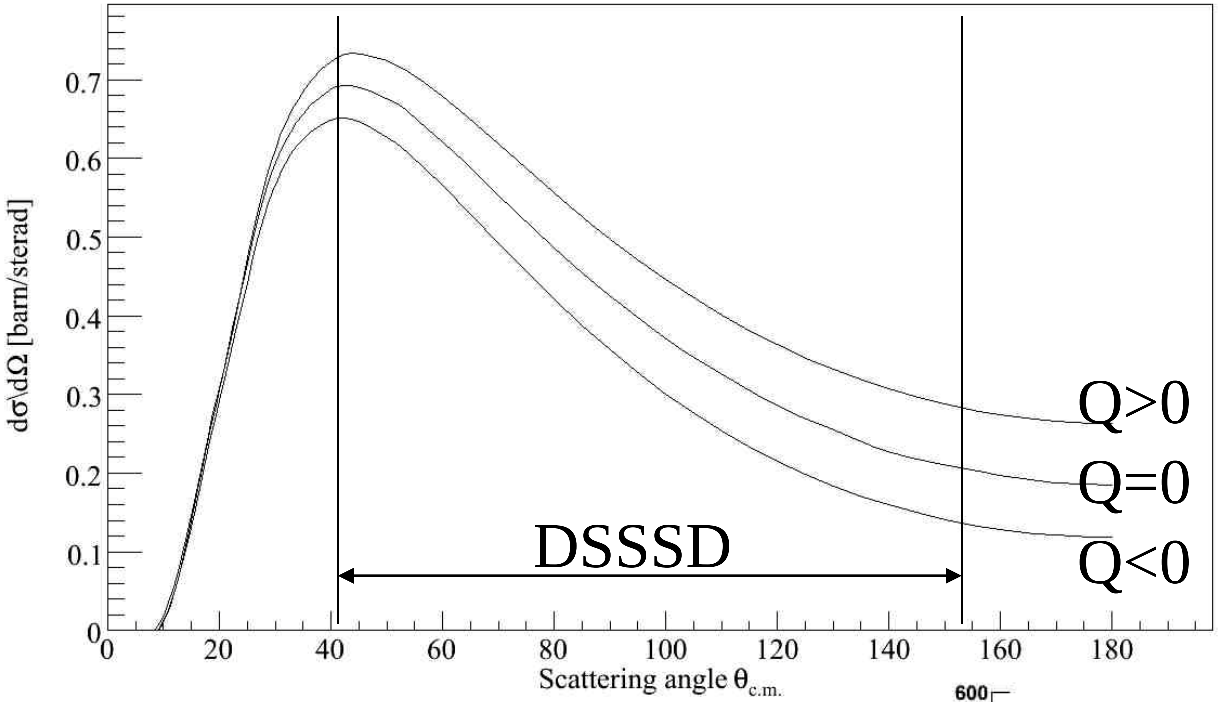


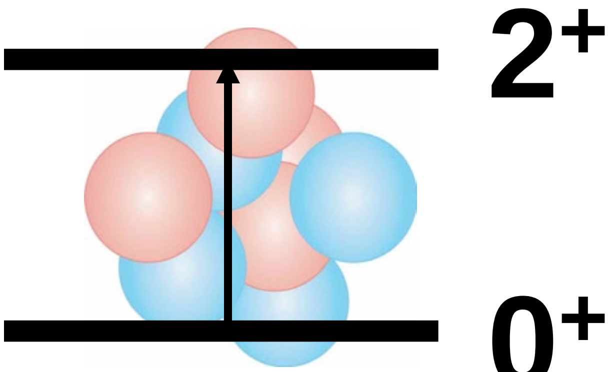




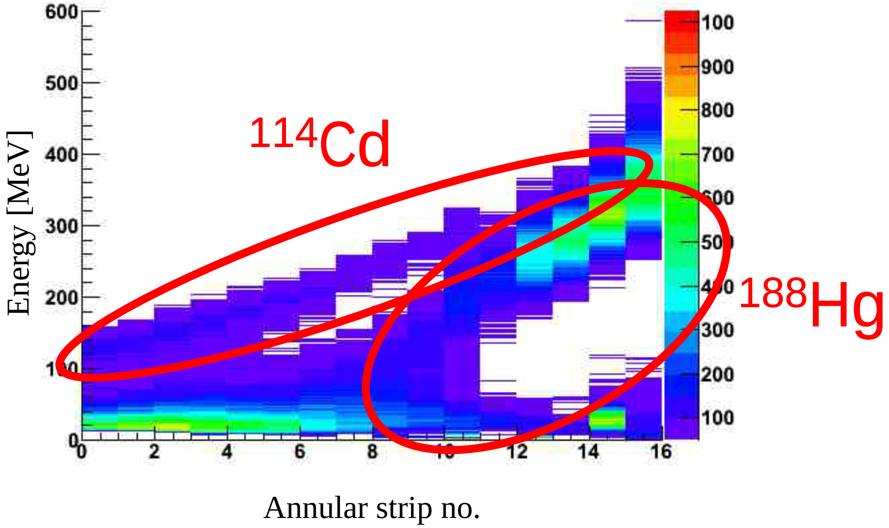
Analysis of $^{182,184,186,188}Hg$

Determination of the quadrupole moment of the first excited 2^+ state



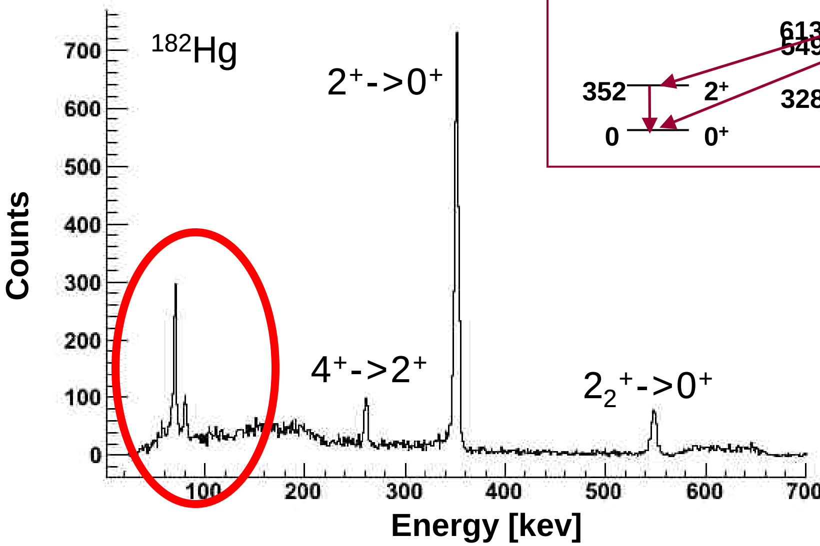


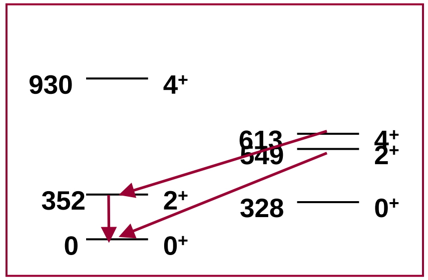
Scanning the c.m. range by gating on different strips!

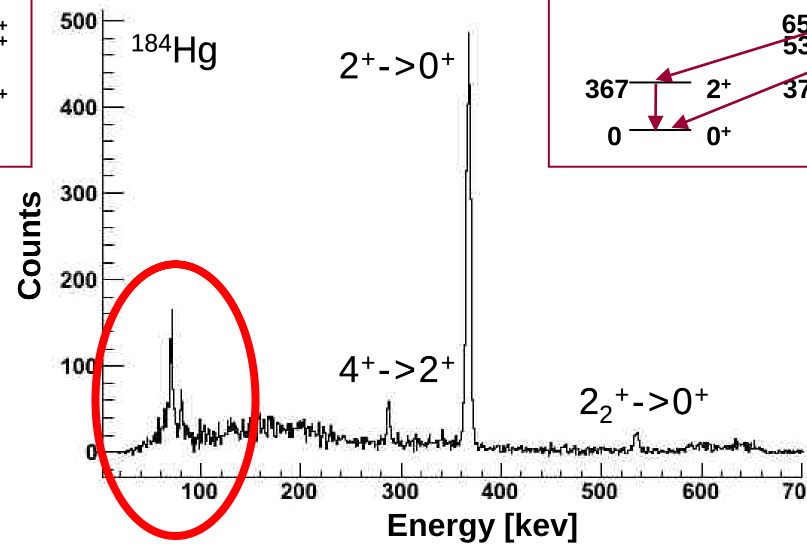


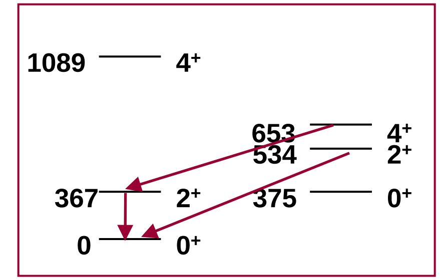
Analysis of $^{182,184,186,188}Hg$

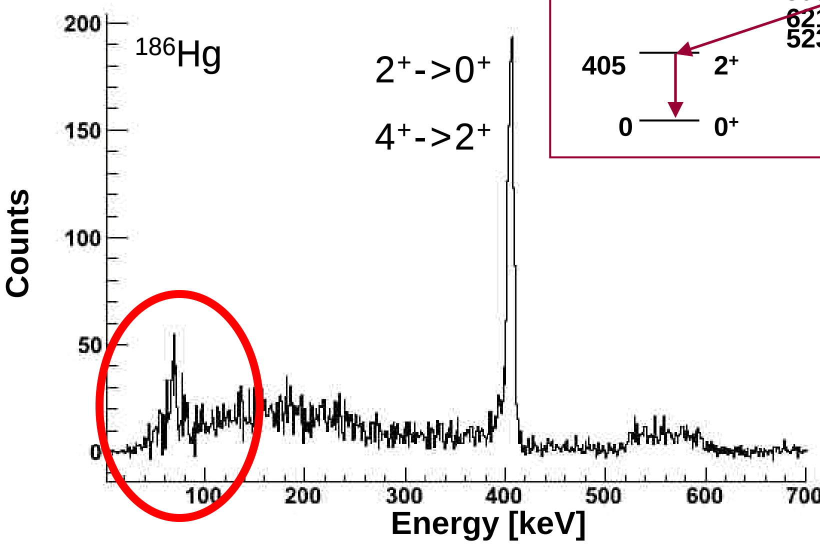
Summary of 2008: 2.85 MeV/u on $^{112,114}Cd$ target

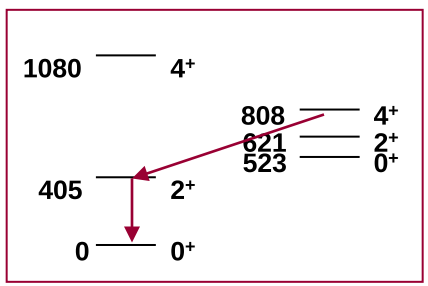


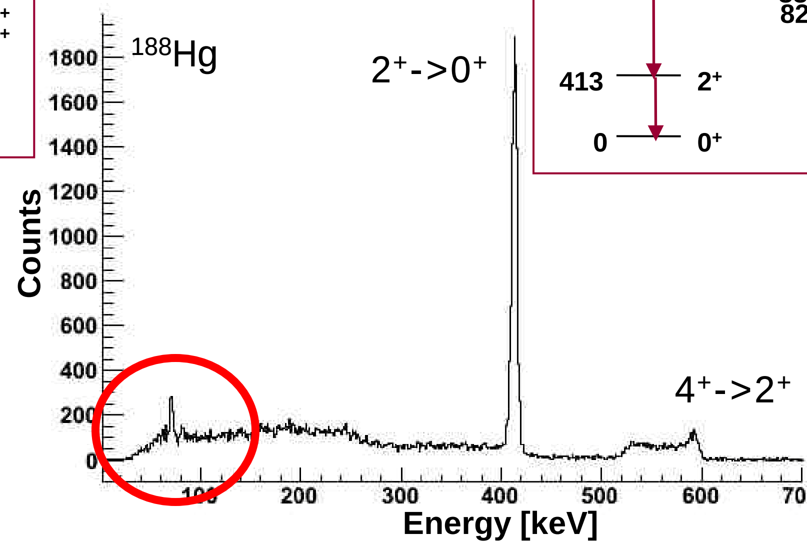


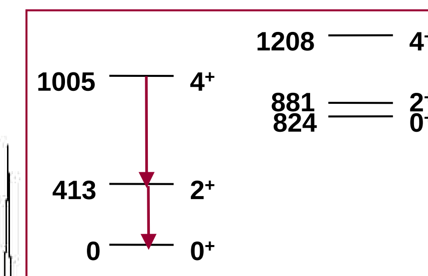






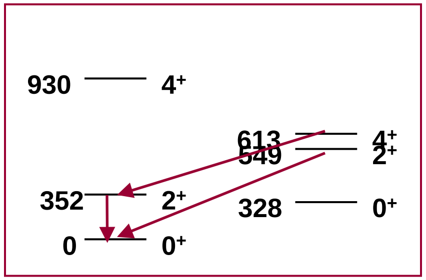


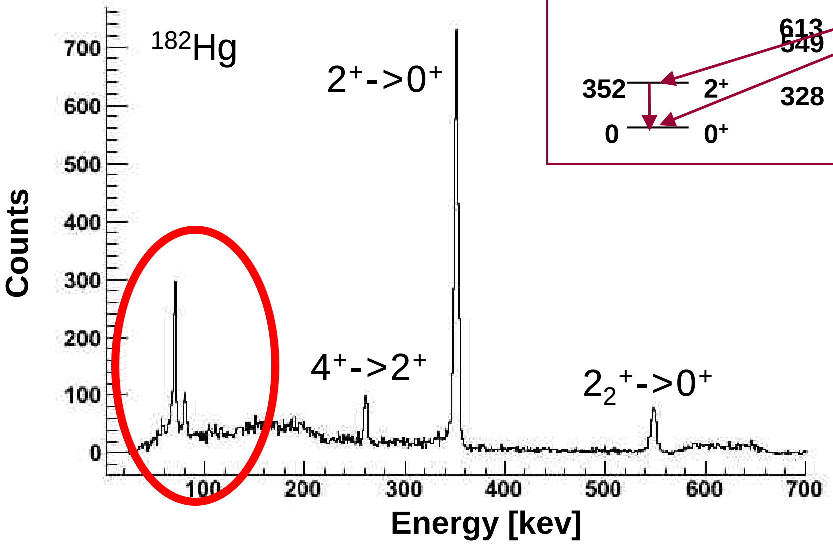




Analysis of $^{182,184,186,188}Hg$

Summer of 2008: 2.85 MeV/u on $^{112,114}Cd$ target

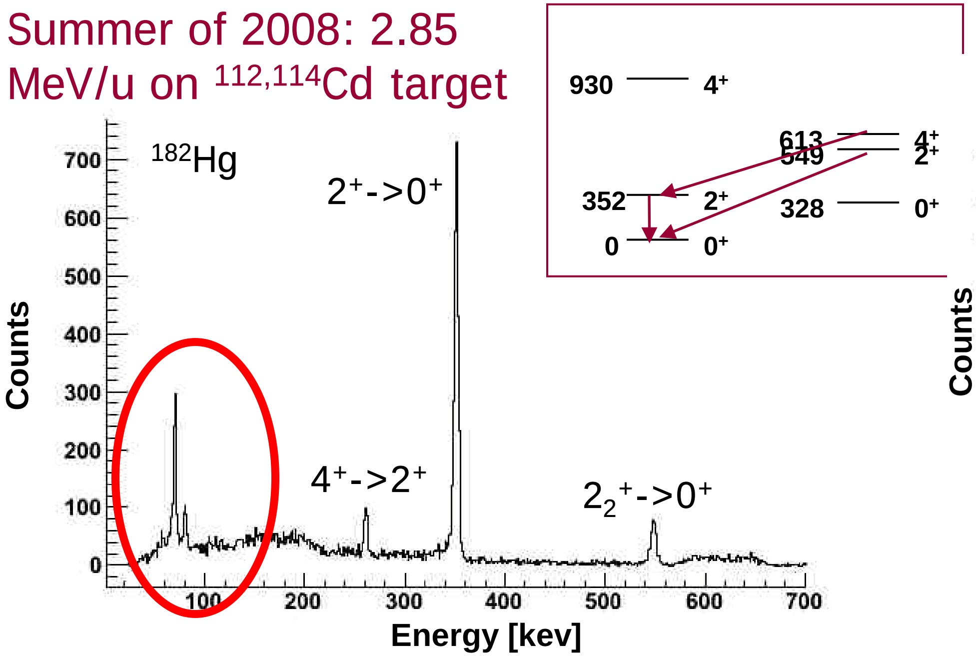


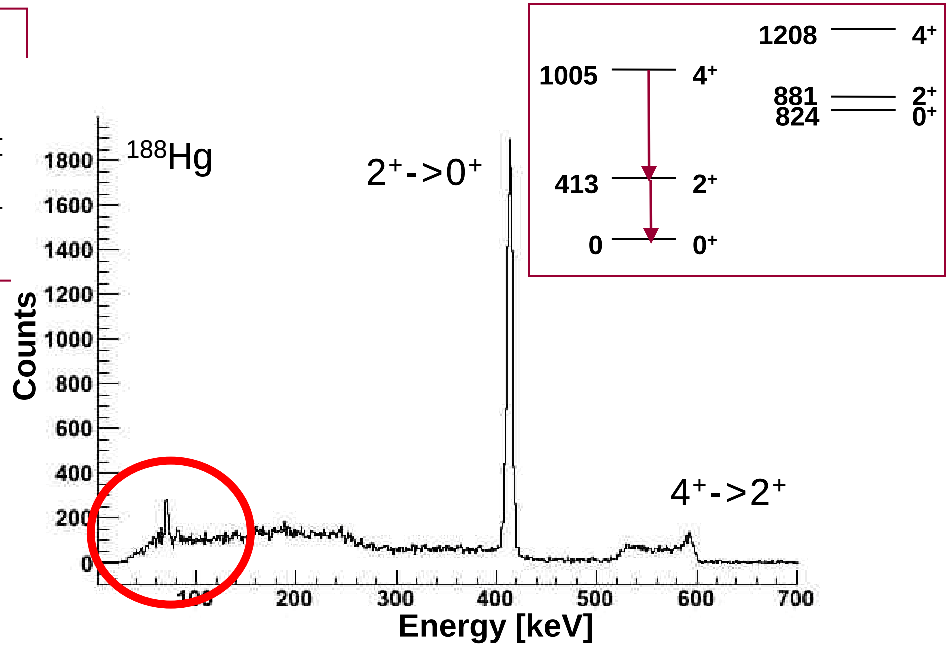


- These are the K_α and K_β X rays originating from mercury.
- They are in prompt coincidence with a particle, so they are due to the collision.
- They are Doppler broadened, so they are emitted in flight.

Analysis of ^{182,184,186,188}Hg

Summer of 2008: 2.85 MeV/u on ^{112,114}Cd target





Conversion + E0 from $2^+_2 \to 2^+_1$ and $0^+_2 \to 0^+_1$

$2^+_2 \to 2^+_1$ estimation from coincidences with $2^+_1 \to 0^+_1$ gamma

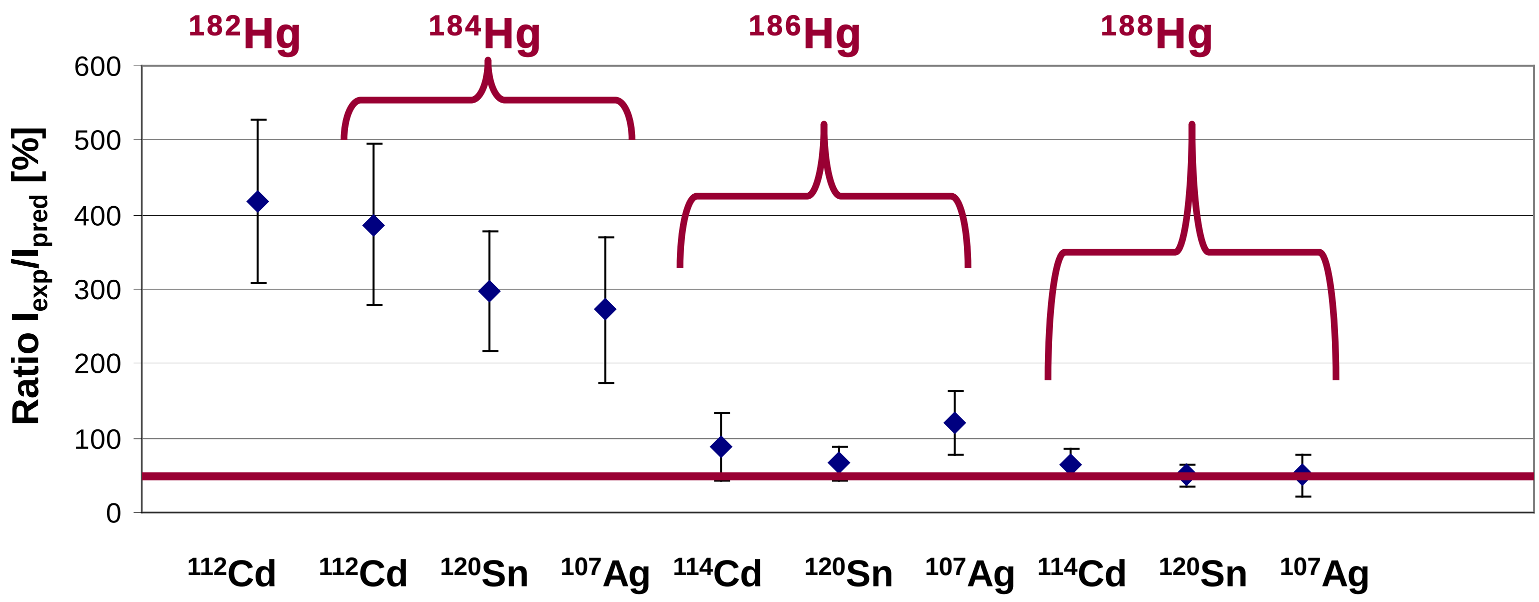
Conversion from the observed transitions cannot explain the amount of X rays.

Analysis of $^{182,184,186,188}Hg$

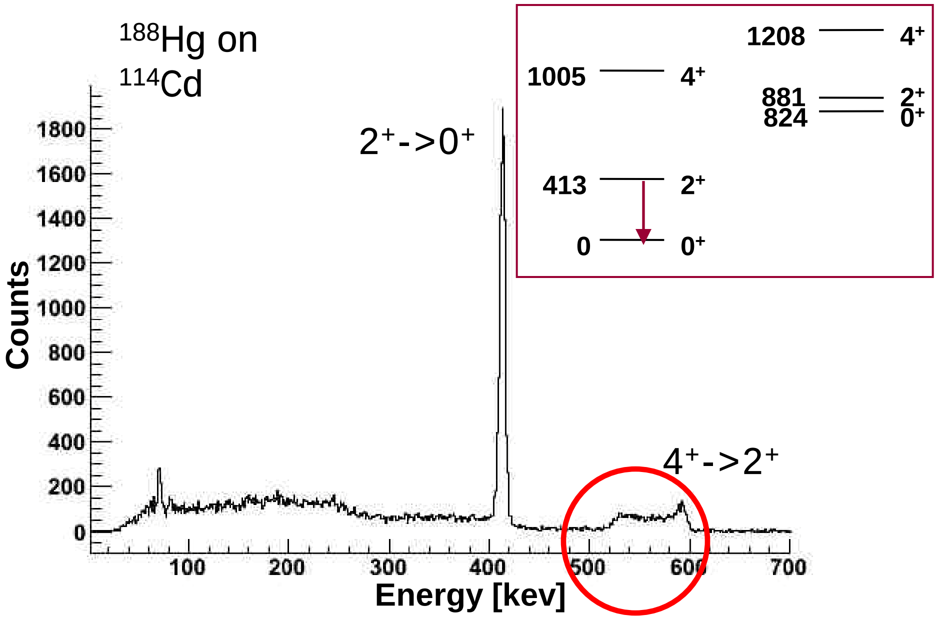
- Heavy ion induced K vacancy creation
- The cross sections have been measured in the mercury region.

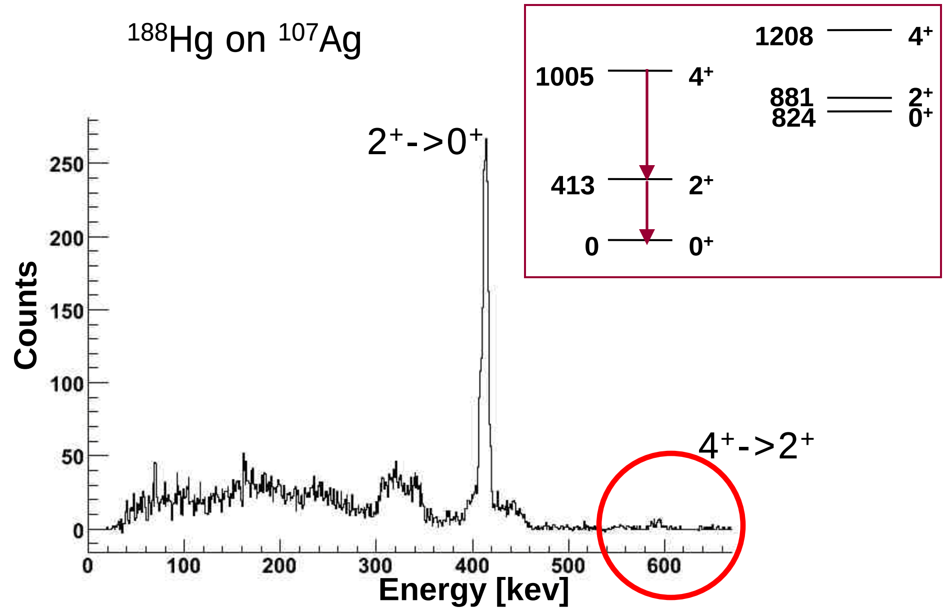
  H.-H. Behncke et al., Z. Phys. A 289, 333 (1979), R. Anholt et al., Phys. Rev. A 16, 190 (1977).

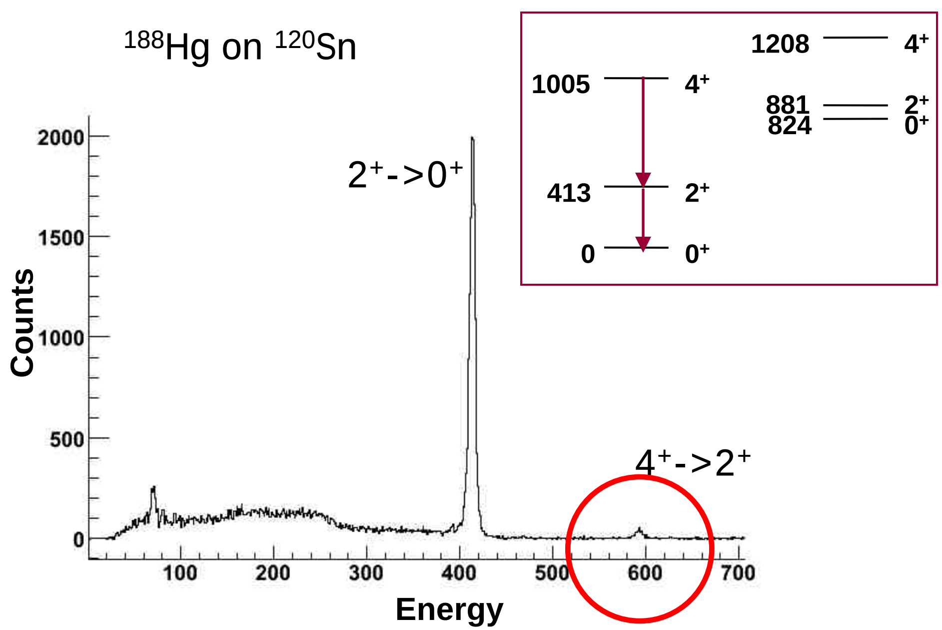
- The gamma energy efficiency at low energies has been determined.

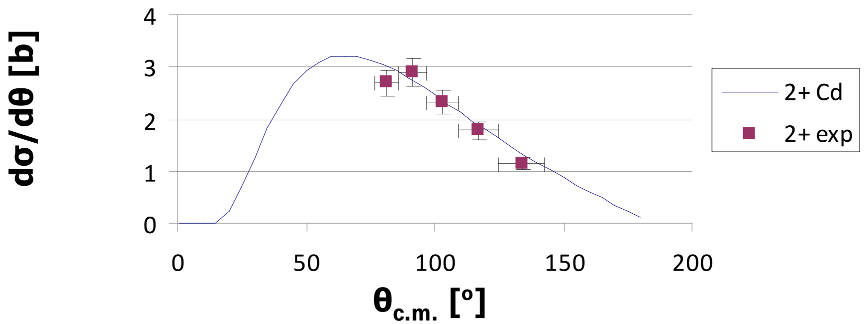


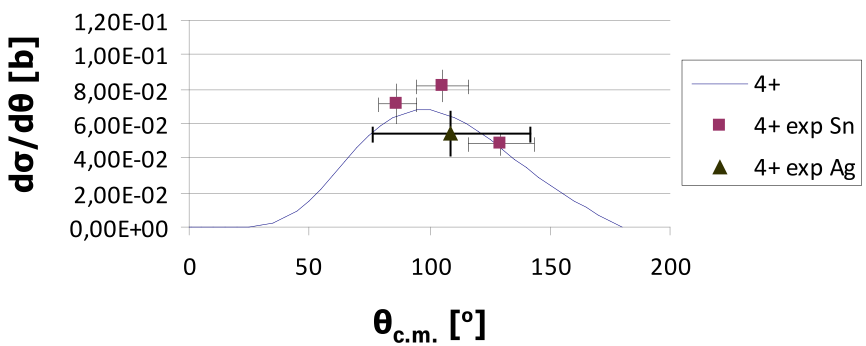
Analysis of $^{182,184,186,188}Hg$









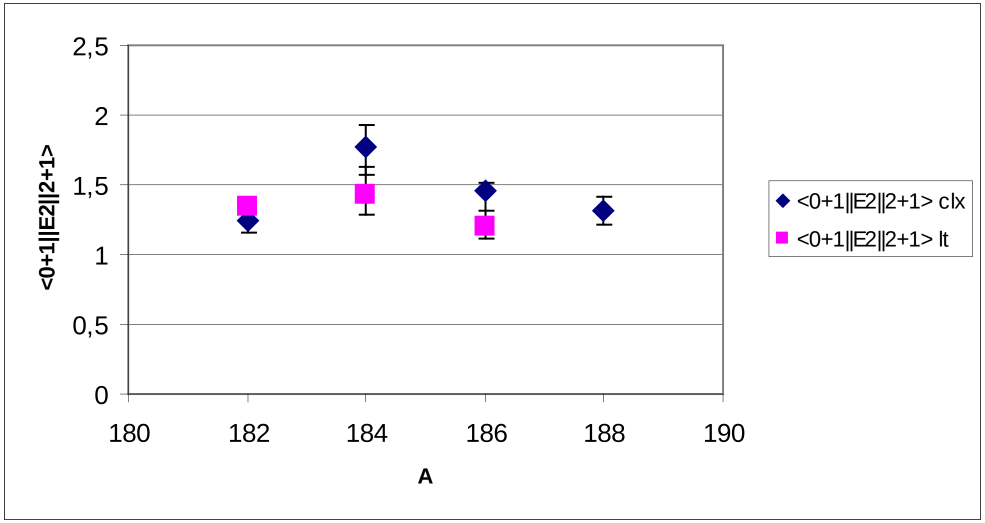


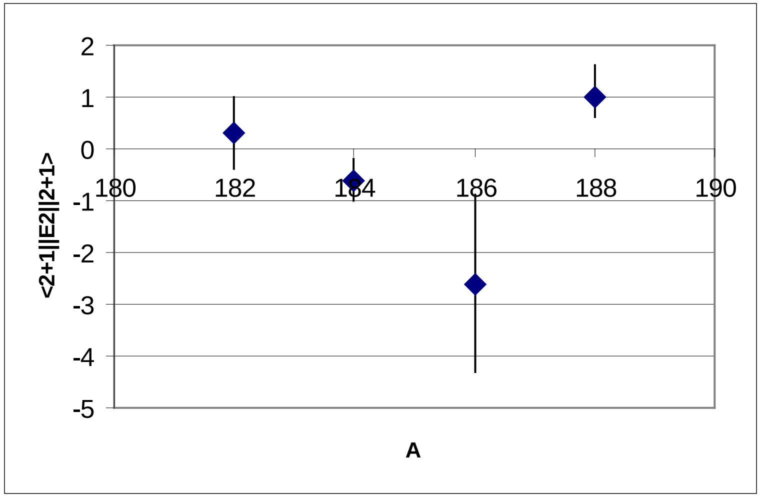
Analysis of ^{182,184,186,188}Hg

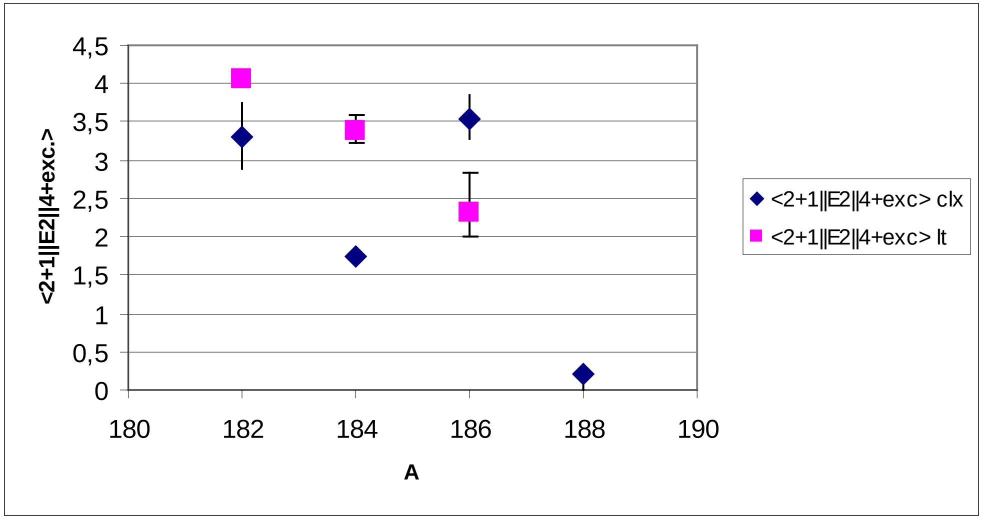
- Analysis using GOSIA without known lifetimes.
- Branching ratios

Matrix element	^{182}Hg	^{184}Hg	^{186}Hg	^{188}Hg
$<0_1^+\|\|E2\|\|2_1^+>$	$1.24^{0.09}_{0.08}$	$1.77^{0.16}_{0.20}$	$1.46^{0.05}_{0.23}$	$1.31^{0.10}_{0.10}$
$<0_1^+\|\|E2\|\|2_2^+>$	$0.44^{0.02}_{0.01}$	$0.72^{0.03}_{0.01}$	<0.06	<0.05
$<2_1^+\|\|E2\|\|4_{g.s.}^+>$		$1.87^{0.16}_{0.10}$	$1.83^{0.04}_{0.04}$	$2.07^{0.08}_{0.08}$
$<2_1^+\|\|E2\|\|0_2^+>$	$1.70^{0.16}_{0.19}$	$1.13^{0.15}_{0.15}$	$1.46^{3.6}_{0.4}$	<0.09
$<2_1^+\|\|E2\|\|2_2^+>$	$2.25^{0.14}_{0.16}$	$0.6^{0.3}_{0.3}$	<1.4	<0.18
$<2_1^+\|\|E2\|\|4_{exc.}^+>$	$3.31^{0.44}_{0.43}$	$1.73^{0.08}_{0.09}$	$-3.53^{0.32}_{0.26}$	<0.2
$<4_{g.s.}^+\|\|E2\|\|2_2^+>$		$4.49^{0.29}_{0.34}$	$-1.96^{0.12}_{0.18}$	<3.3
$<0_2^+\|\|E2\|\|2_2^+>$	<0.72	<3.9	<7.3	<10
$<2_2^+\|\|E2\|\|4_{exc.}^+>$		$1.78^{0.21}_{0.16}$	$5.34^{2.7}_{0.9}$	
$<2_1^+\|\|E2\|\|2_1^+>$	$0.3^{0.7}_{0.7}$	$-0.6^{0.4}_{0.4}$	$-2.6^{1.7}_{1.7}$	$1.0^{0.6}_{0.4}$

Analysis of ^{182,184,186,188}Hg







W.C Ma et al., Phys. Lett. 167 (1986) 277.

Proetel et al., Phys. Lett. 48 (1974) 102.

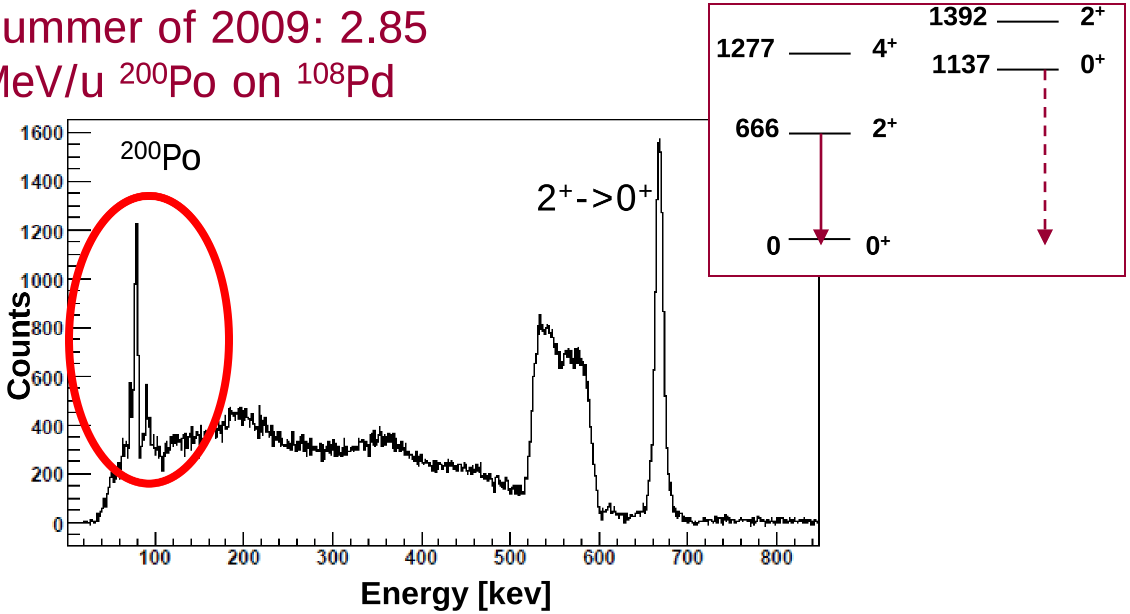
T. Grahn et al., Phys. Rev. C80 (2009) 014324

Conclusion and future perspectives

- X rays have been investigated (cfr. Po, Rn, Pb).
- Diagonal and transitional matrix elements have been extracted.
- Lifetime measurements have been performed on $^{184,186,188}Hg$ at ANL.
- Comparison with theory (P.-H. Heenen, K. Heyde,...)

Analysis of ^{182,184,186,188}Hg

Summer of 2009: 2.85 MeV/u ^{200}Po on ^{108}Pd



- No X rays were observed in coincidence with the 2^+_1 -> 0^+_1 transition.
- Are these X rays originating from excitation to the 0^+_2 state?
- The excitation path 0^+_1 -> 2+1 -> 0+2 would require an unphysically large <2+1||E2||0+2> matrix element.